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DESIGN AND FABRICATION OF A LOW-COST ASSISTIVE DEVICE TO SUPPORT THE BASIC MOVEMENTS FOR ELDERLY PEOPLE

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ABSTRACT

Generally, the musculo-skeletal movements become weak in the elderly people (aged above 70) and then even the basic hand movements such as lifting necessary objects and pushing/pulling activities become a very difficult job. They constantly need help and support from other people such as family members. A wheel chair which is operated on battery power and is maneuvered by joystick for turning left or right has been developed to assist the elderly people using the technologies available in recent days. This refers to the development of a device, which will aid the mobility of the elderly people to carry out basic movements like walking, getting up, and sitting down all by themselves. The seat of the wheelchair will recline and help the person to get off the wheelchair without anyone's help. Many similar devices that exists as of now has been made entirely for a different purpose, and operate quite differently, and are very expensive and not affordable as well. However, if this proposed device come to existence, it will be very useful for the elderly people especially of the middle class who cannot afford those high-tech existing models, which do not serve the exact purpose as they are usually made for differently-abled individuals.

KEYWORDS: Electric Wheelchair, Assistive Device, Reclining Seat, Arduino, Relays & Joystick Control

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Original Article

INTRODUCTION

The numbers of old people and differently abled individuals who use wheelchairs have greatly increased in the recent days [1]. For the wheelchair users, they need continuously someone to help them in getting the wheelchair moving [2]. After several studies and survey it is proved that both children and adults benefit substantially from access to means of independent mobility. Though many disabled people are satisfied with traditional manual or powered wheelchairs, there is a segment of disabled community who find it difficult or impossible to use wheelchairs independently [3]. Moreover, wheelchairs are always tailored for disabled people rather than old people. The old people were used to being independent once upon a time and now when they require someone's help to perform their day to day activities; they lose their confidence and tend to feel insecure [4].

The wheelchairs which are normally available are either the extremely cheaper ones which requires assistance during its usage or the very expensive higher end models tailored for completely disabled individuals. So they do not serve the purpose for the old people.

They just need a normal wheelchair that can carry them from one place to another, and when they want to get off the wheel chair, it should assist them in doing that. Wheelchairs that can be modified have always been in existence [5]. And thus, we came up with this idea of a powered wheelchair with a reclining seat which will help the person to come out of the wheelchair with ease and not much effort on the knees. At the same time, all the other unnecessary features are excluded so as to keep the cost minimal.

THE CONCEPT

The idea is to create a joystick controlled electric wheelchair which will run on batteries. The seat will be backed by a pneumatically actuated piston assembly which will automatically push the person out of the wheelchair when he/she is trying to get off the wheelchair. There is no other wheelchair which serves this purpose till date. The other wheelchairs that have reclining seat are used for making disabled individuals stand up within the wheelchair. It does not help them get off the wheelchair. Moreover, such wheelchairs hit really hard on the pocket. So, it would not be affordable at all.

Components used

There are various components which were used to bring the wheelchair into existence. These components were obtained from various sources. The components include,

Manual Wheelchair

A basic manual wheelchair was used as a framework to modify and fit the other components.

Pneumatic Lifting Seat

This is the combined piston and seat assembly made by Uplift Technologies. Usually should not to be used along with wheelchair when it is bought separately. But we will be modifying the wheelchair in a way that it can be used with this type of seat. The seat is shown in figure 1.

Wheelchair Motors

Wheelchair motors are special type of motors tailor made especially for wheelchairs. These are high torque brushed DC motors with a gear assembly to increase the torque and reduce the rpm. These motors have electromagnetic brakes built in which engage the brakes as soon as the supply is remove and thereby stays as a safety feature. A pair of wheelchair motors is shown in figure 2.

Figure 1: Pneumatic Lifting Seat.

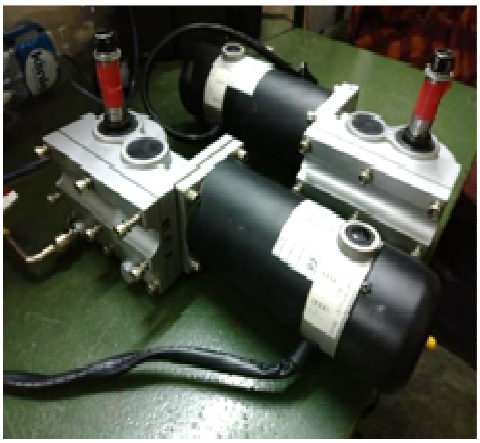

Figure 2: Wheel Chair Motors.

Table 1: Specifications of the Motor

Features of the Motor		
Sl. No	**Feature**	**Value**
1	Operating Voltage (VDC)	24V
2	Output power (W)	330
3	No-Load Current (A)	<= 3
4	Motor Speed =/-5% (RPM)	4600
5	No-Load Output Speed (RPM)	135
6	Gear Ratio	26.25:1
7	Sound Level (db.(A))	<= 58
8	Break Torque (Nm)	>= 33.4
9	Gear Motor Rated Torque (Nm)	16.95
10	Motor OD (mm)	79
11	Output Shaft OD mm)	17 (with 6mm keyway and key)

Arduino Uno

The Arduino Uno was used to control the direction of rotation of the motors through a set of relays by taking input from a joystick. Figure 3 shows an Arduino Uno along with its various connection labeling.

Dual Axis Joystick

The Dual Axis Joystick was used to take the directional input from the user and the signal was sent to Arduino. A dual axis joystick is shown in figure 4.

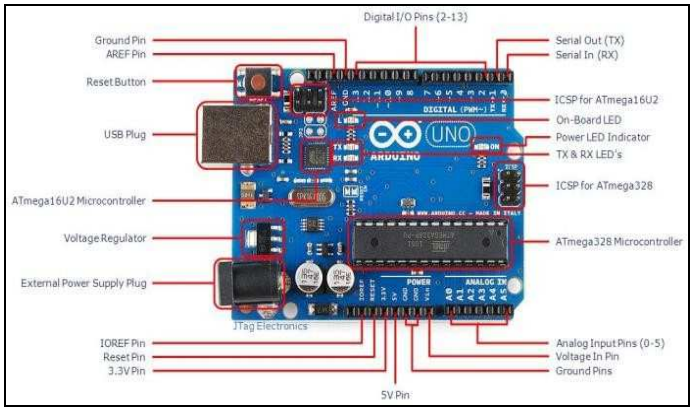

Figure 3: Arduino Uno.

Figure 4: Dual Axis Joystick.

Relays

There were 2 types of relays used in this project. One that operates on 5v and another that operates on 12v. Both of these relays were used to isolate the high-power motor circuit from the low power Arduino circuitry. An automobile relay is shown in Figure 5.

Other Miscellaneous Components

The other components we used were a set of powered wheelchair wheels, a pair of 12V 9AH Lead Acid Batteries and normal wires and cables for connections.

Figure 5: Automobile Relay.

THE ELECTRONICS BEHIND

12V Relay Circuit

Both of the motors were isolated from the low power circuit by means of 4 high power 12v relays (Figure 6) which are normally used in automobiles. The relay circuit was designed in such a way that they can be used to control the direction of rotation of the motors. The Motors are connected to the common point of the relays. The NO Pin of the Relays are connected to the –ve of the battery and the NC Pin of the relays are connected to the +ve of the battery.

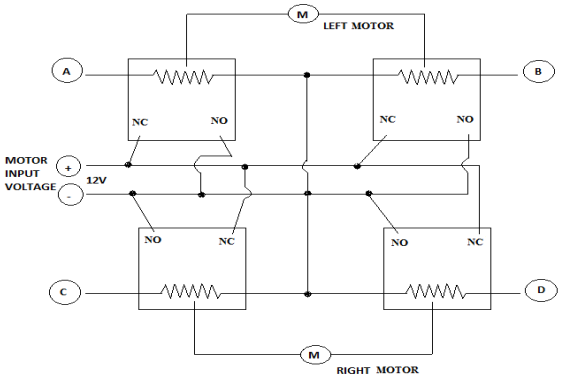

Figure 6: 12V Relay Circuit.

5V Relay Circuit

It is clear that Arduino can set a pin high by raising the voltage to 5V. In our application we need 12V to activate the motor. Hence we use a 5V relay in such a way that each output can be converted to 12V from 5V. The Input pins are from the Arduino, in our case they are Left, Right and Forward. These inputs are used to power the relays, so each time a 5V is generated by the Arduino the particular relay gets powered. To convert these to 12V we use a simple technique. We give 12V to the common pin and when the relay is powered by the 5V the common pin and NO pin switch to form a circuit inside the relay this leads to the pin NO being high that is having 12V. In this way the desired output is obtained. Refer Figure 7 for the circuit diagram.

The Diode Assembly

This Diode assembly helps to reduce the number of outputs from the Arduino. It combines the signal for forward and reverse direction for two motors. In this way for left direction we can spin the left motor in reverse direction and right motor in forward direction. In this way we reduce the space needed to turn. This is a very simple but efficient method of achieving this kind of output. The diode assembly circuitry is shown in figure 8.

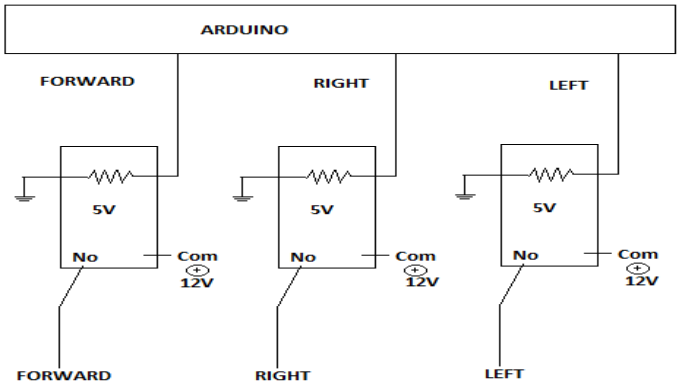

Figure 7: Relay Circuit (5V).

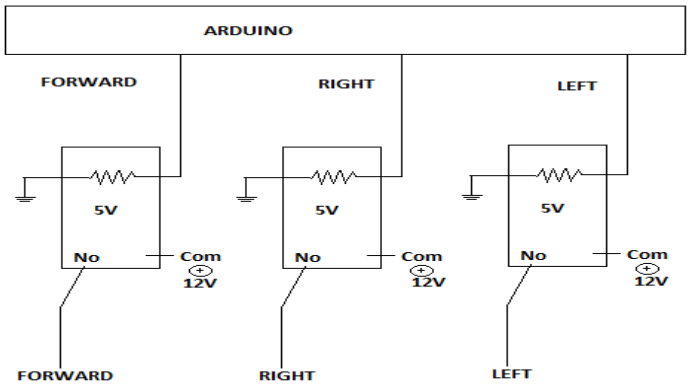

Figure 8: Diode Assembly.

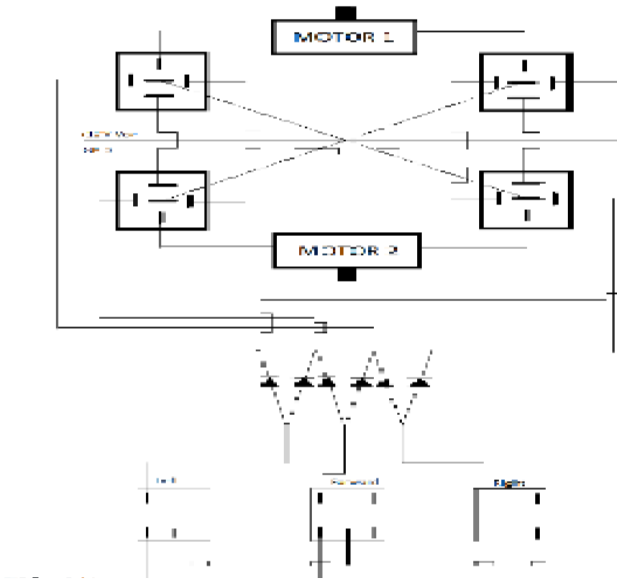

Figure 9: Circuit Block Diagram.

Block Diagram

The block diagram of the entire circuit put together is shown in figure 9.

WHEEL CHAIR DESIGN & ANALYSIS

The wheelchair was initially designed using SolidWorks 2016 and later when the final wheelchair was made it was redesigned using Autodesk Inventor. The wheelchair was analysed using ANSYS. The initial rough design is shown in figure 10 and the final design is shown in figure 11. The analysed wheelchair frame is shown in figure 12 to 16.

Figure 10: Initial Design.

Figure 11: Final Design.

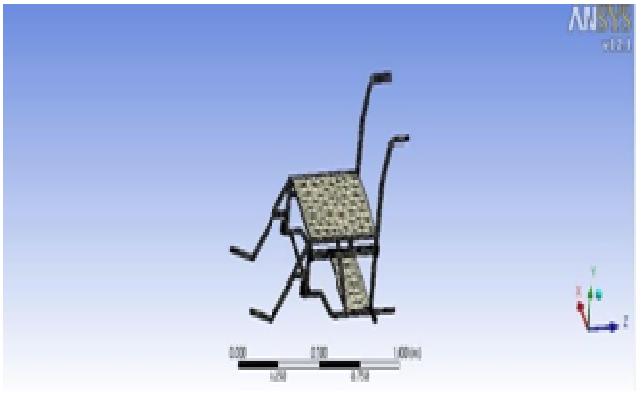

Figure 12: Meshed Frame.

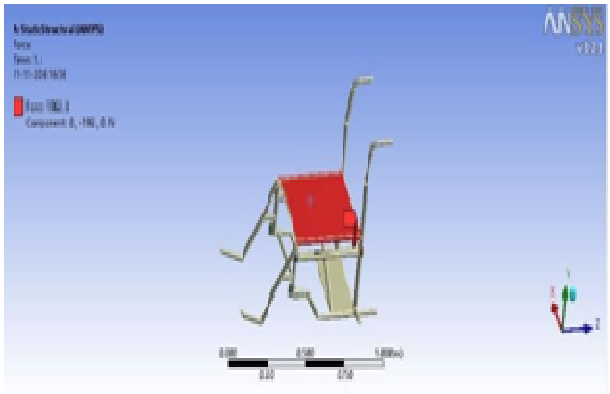

Figure 13: 200kg Loaded Frame.

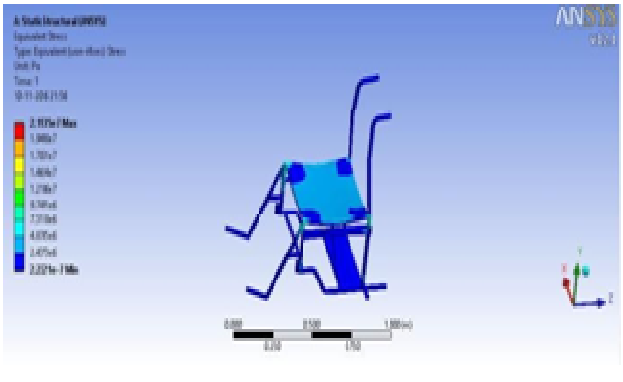

Figure 14: Maximum Stress 0.021 GPa.

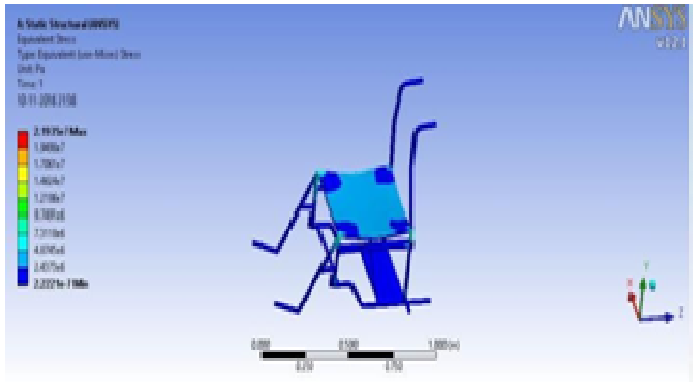

Figure 15: Maximum Strain 1.096µ.

The load applied on the frame was 200kg. This includes the motors and the batteries as well. The maximum deformation was found to be 1.32µm. The maximum stress and strain was 0.021 GPa and 1.096µ respectively.

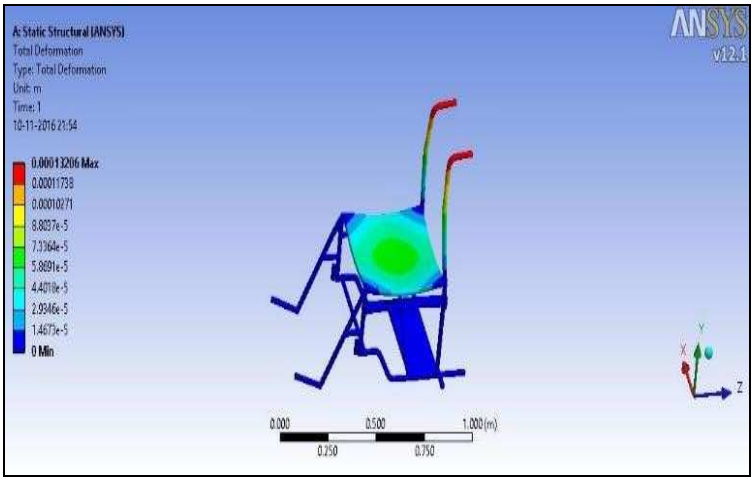

Figure 16: Maximum Deformation 1.32µm.

WORKING MODEL

The initial basic manual wheelchair is shown in Figure 17. Mild Steel was used wherever modified parts were needed. The wheelchair needs to be foldable to increase the portability. Hence, the lifting seat was attached to the wheelchair by means of a plate which can be assembled to the wheelchair when needed and can be removed when the wheelchair needs to be folded. This metal plate is shown in Figure 18. The seat was attached to the plate by means of nuts and bolts. Similarly, to hold the battery another similar metal plate was made. The wheels needed to be replaced with thicker ones meant for powered wheelchair. These wheels have much higher density and are meant to withstand higher loads. They are shown in Figure 19. The motors were attached on the rods at the back of the wheelchair by means of 8 bolts per motor. These motors can be engaged and disengaged by means of a lever when the wheelchair needs to be manually operated. The way these motors were fixed to the wheelchair is shown in figure 20. The final wheelchair which was made as outcome of this project is shown in figure 21.

Figure 17: Basic Manual Wheelchair.

Figure 18: Metal Plate for the Seat.

Figure 19: High Density Powered Wheelchair Wheels.

Figure 20: Wheelchair Motors Fixed to the Frame.

Figure 21: Final Assembled Wheelchair.

CONCLUSIONS

Thus, a cost effective foldable powered wheelchair which can be operated using joystick was successfully designed and fabricated. The seat automatically reclines when somebody sits on it and it also pushes the person out of the wheelchair when he/she wants to get down. This wheelchair will be of great help for the aged middle class people who cannot afford the expensive high end wheelchair models. This wheel chair was also tested on the elderly people in an old aged home and dedicated to an elderly woman who could not move around easily.

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